MALACOLOGY.—*Recent species of the prionodont pelecypod* Cucullaea[1]. DAVID NICOL, U. S. National Museum.

A review of the living species of *Cucullaea* has not been made since Lamy (1907, pp. 306, 307) made one more than 40 years ago, although Iredale (1939, pp. 250–252) thoroughly reviewed the species names.

This study is the second of a series on relict marine bivalve families, and its scope is the same as that made on the fimbriids. The cucullaeids, like the fimbriids, have a history dating back to the early Jurassic. During Jurassic and Cretaceous times the cucullaeids were abundant in number of species and world-wide in distribution. Rapid decline became apparent after the early Eocene, and the family has since been much restricted in its distribution and number of species. Today the group is found in the Indian Ocean and the western part of the Pacific Ocean. From this brief history of the cucullaeids, it is interesting to note the amazing parallelism with the fimbriids. In minor details there are differences, and the two groups do not quite occupy the same ranges today; but the over-all picture is much alike for both families. Ecologic factors do not enter into this parallelism if we consider the evidence on the basis of the living species.

Genus **Cucullaea** Lamarck, 1801

Genotype.—Cucullaea auriculifera Lamarck, 1801 = *Arca cucullata* Röding, 1798 = *Arca cucullus* Gmelin, 1791 = *Arca labiata* Solander, 1786. Subsequent designation, J. G. Children, 1823, p. 318.

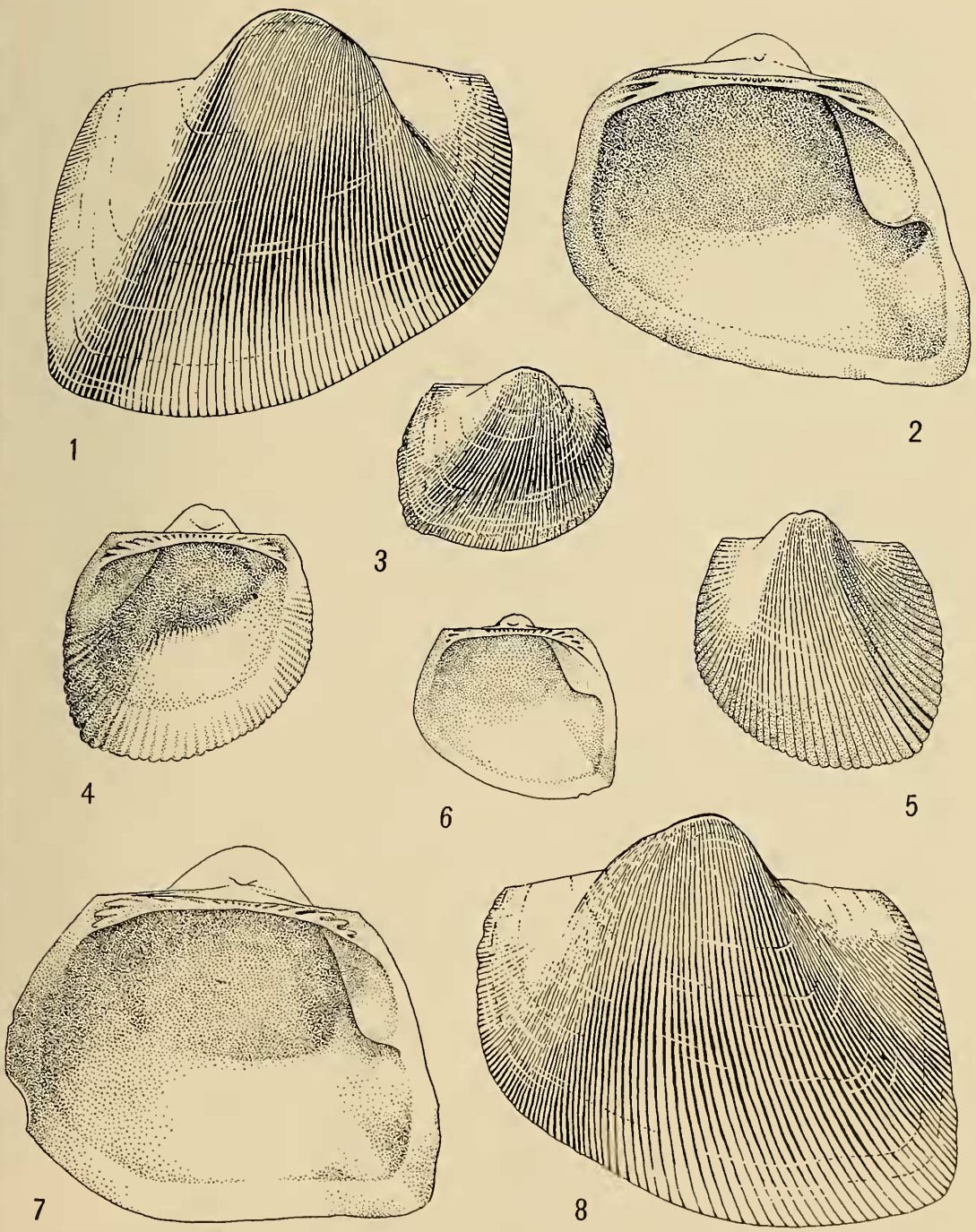
Winckworth (1944, p. 231) listed two earlier genotype designations for *Cucullaea*, but neither of these is valid. Schmidt (1818, p. 65) designated *Arca cucullus* Gmelin as the genotype, but this species name was not included in Lamarck's original description, nor can *Arca cucullus* Gmelin be considered as an objective synonym of *Arca cucullata* of Chemnitz. Fleming (1818, p. 306) made the following statement concerning *Cucullaea*: "In the genus *Cucullaea*, the teeth of the hinge are similar to the Arcae, but at each extremity there are three or four transverse parallel ribs. It is represented by the *Arca cucullata* of Chemnitz. Conch. VII, p. 174. tab. 55, f. 526–528." This cannot be construed as a genotype designation, and, furthermore, it is certainly not clear that Fleming was referring to types in the modern sense.

Cucullaea labiata (Solander)

Figs. 1–8

1786. *Arca labiata* Solander, Catalogue Portland Museum: 185, lot 3947.
1789. *Arca concamera* Bruguière, Encyclopédie méthodique, histoire naturelle des vers, texte 1 (aber-con): 102, 103.
1791. *Arca cucullus* Gmelin, Systema naturae, ed. 13, **1**(6): 3311.
1798. *Arca cucullata* Röding, Museum Boltenianum, pt. **2**: 173, no. 207.
1801. *Cucullaea auriculifera* Lamarck, Système des animaux sans vertèbres: 116.
1835. *Arca concamerata* Deshayes, Histoire naturelle des animaux sans vertèbres, ed. 2, **6**: 454.
1846. *Cucullaea granulosa* Jonas, Proc. Zool. Soc. London, 1846, pt. **14**: 34, 35.
1857. *Cucullaea concamerata* (Deshayes), Deshayes, Traité élémentaire de conchyliologie **2**: 379, 380, pl. 36, figs. 12, 13.
1860. *Cucullaea plicata* Theobald [nomen nudum], Catalogue Recent shells Museum Asiatic Society of Bengal: 126.
1869. *Cucullaea concamerata* (Deshayes), Reeve, Conchologia iconica **17**: Genus *Cucullaea*, species 1, fig. 1.
1869. *Cucullaea granulosa* Jonas, Reeve, Conchologia iconica **17**: Genus *Cucullaea*, species 2, figs. 2a, b.
1869. *Cucullaea auriculifera* Lamarck, Reeve, Conchologia iconica **17**: Genus *Cucullaea*, species 3, fig. 3.
1891. *Cucullaea concamerata* (Deshayes), Kobelt, Systematisches Conchylien-Cabinet von Martini und Chemnitz, Die Gattung *Arca* L., **8**(2): 5, 6, pl. 1, figs. 3, 4, pl. 5, figs. 1, 2.
1891. *Cucullaea granulosa* Jonas, Kobelt, Systematisches Conchylien-Cabinet von Martini und Chemnitz, Die Gattung *Arca* L., **8** (2): 6, 228, pl. 1, fig. 5.
1907. *Cucullaea concamerata* (Deshayes), Lamy, Journ. Conchyl. **55**(3): 306.
1907. *Cucullaea granulosa* Jonas, Lamy, Journ. Conchyl. **55**(3): 306, 307.
1909. *Arca* (*Cucullaea*) *concamerata* Deshayes, Lynge, Danish expedition to Siam 1899–1900, IV: Marine Lamellibranchiata: 128.
1930. *Cucullaea vaga* Iredale, Rec. Australian Mus. **17**(9): 385.
1939. *Cucullaea labiata petita* Iredale, Great Barrier Reef expedition 1928–29, Scientific Reports, **5**(6): Mollusca pt. 1: 250–252, pl. 2, figs. 1a, 17, 17a, 17b.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received July 16, 1950.



Figs. 1–8.—*Cucullaea labiata* (Solander) (all specimens are in the U. S. National Museum Collection): 1, Exterior of right valve, × $\frac{5}{6}$, Torres Straits, U.S.N.M. no. 149920; 2, interior of right valve, × $\frac{5}{6}$, India, U.S.N.M. no. 149921; 3, exterior of right valve, × $\frac{5}{6}$, Manila Bay, Luzón, U.S.N.M. no. 255093; 4, interior of left valve, × $3\frac{1}{3}$, Balukbaluk Island, Sulu Archipelago, U.S.N.M. no. 293754 (note groove on umbonal margin and arrangement of teeth in this small specimen); 5, same valve as Fig. 4, exterior, × $3\frac{1}{3}$; 6, interior of right valve, × $\frac{5}{6}$, near Cebu, U.S.N.M. no. 236880; 7, interior of right valve, × $\frac{5}{6}$, near Pratas Island, U.S.N.M. no. 255098; 8, same specimen as Fig. 1, exterior, left valve, × $\frac{5}{6}$.

Description.—The shell is porcellaneous and thin, and the thick, velvety periostracum is better developed in cooler water. The valves are unequal, the left valve overlapping the right along the posteroventral and ventral borders. Valve outline can be subquadrate, subtrapezoidal, or subtrigonal, whereas the posterior side is always flattened and more or less truncated. The valves are subequilateral and do not gape. In young shells the radial ribs are raised and tend to split, and new ribs form in the interspaces. The radial ribs are usually broader than the interspaces. There are concentric raised threads at regular intervals. In mature specimens the radial ribs tend to flatten and widen; less splitting occurs. Concentric threads give the ornamentation a cancellate appearance. On some specimens the radial ribs are broader and flatter on the left valve. The variation in ornamentation is great. On large shells the crenulations on the interior ventral border are small and numerous. On small shells these crenulations are better marked and are also seen on the anteroventral and posteroventral margins. In the smallest specimens these crenulations are strongly marked, and the ribs are reflected on the interior of the shell. The beaks are orthogyrate. In young specimens the umbonal area shows a groove located slightly anterior to the center, but it is difficult to see on large shells. This shallow groove is not confined to the cucullaeids but is well developed in many other prionodonts and may have systematic importance. The ligament is external and amphidetic, although slightly more of the ligament lies anterior to the beaks than posterior to them. The ligamental area is flat and shallow. The ligament shows only fine lines running parallel to its long axis, and the loss of well-developed ligamental chevrons is a late development among the cucullaeids. In small shells the teeth are nearly all the same size and look much like the teeth of *Anadara* and *Glycymeris*. The larger specimens show a reduction in the height of the central part of the hinge plate, and a corresponding reduction in the size of the central teeth makes them look like the blade of a saw. The side teeth become reduced in number to about three or four on each end, become elongate, and are arranged nearly parallel to the ligament. The reduction in the height of the hinge plate is another late development in the cucullaeids. The number of teeth is variable, but on small shells there are about 17, whereas on large ones there may be as many as 30. On some intermediate-sized specimens a few of the teeth are hooked or even chevron-shaped. The posterior side of the hinge plate extends ventrally a little farther than the anterior side, and often there is one more posterior side tooth. On large shells the anterior part of the posterior adductor muscle lies on a built-out flange of shell material; this is not seen in small shells. The posterior side of the cucullaeid is so truncated that in order for the adductor muscle to exert a force to close the valves, the flange appears to be a mechanical necessity. The anterior adductor muscle scar has only a trace of the flange, but the anterior side is not nearly so truncated. The pallial line is integripalliate, with a slight indentation where it joins the ventral part of the flange of the posterior adductor muscle scar. Color variation is considerable among the cucullaeids. Specimens from southern Japanese waters are often deep purple interiorly. One specimen from India is light purple along the posterior margin of the interior of the shell and has a brown and purple streak at the base of the flange for the posterior adductor muscle. Shells from the Philippines are light brown to orange exteriorly. According to Dr. Joyce Allan (personal communication), specimens of *Cucullaea* from northern Queensland waters are splashed with yellow-orange, and those from the cooler waters of New South Wales have darker colors.

Measurements.—Maximum length was measured rather than the length from the middle of the anterior and posterior ends. Height was measured on the basis of the left, or larger, valve. Only specimens with both valves were measured. Measurements, in millimeters, are as follows:

U. S. N. M. no.	*Length*	*Height*	*Convexity (both valves)*
346134A	99.6	78.4	73.4
149920	90.4	72.4	65.8
273673	81.6	67.0	57.9
249497	78.8	65.5	58.2
149921	77.5	63.0	53.7
273673A	77.4	62.9	52.5
346134	71.5	61.4	53.3
236880	38.5	33.3	26.0

Remarks.—There are 110 specimens of Recent cucullaeids in the U. S. National Museum collection. Most of them are small shells dredged by the *Albatross*.

Locality data.—Specimens from the following localities are in the U. S. National Museum collection:

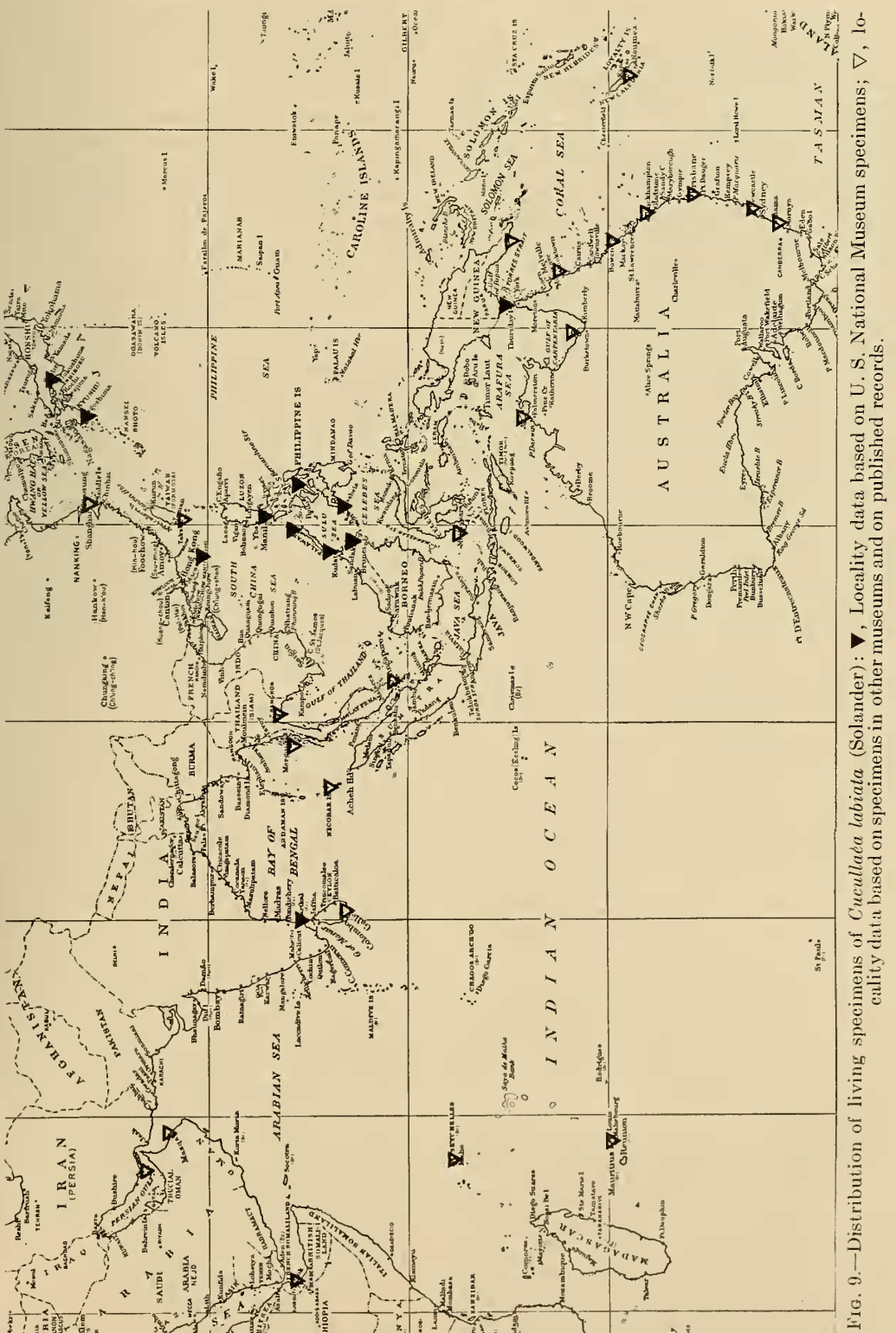


Fig. 9.—Distribution of living specimens of *Cucullaea labiata* (Solander): ▼, Locality data based on U. S. National Museum specimens; ▽, locality data based on specimens in other museums and on published records.

ALBATROSS DREDGING STATIONS

D.5134—Sulu Archipelago near Basilan Island, Balukbaluk Island (N.), S. 59° W., 6.25 miles (6° 44′ 45″ N., 121° 48′ E.). 25 fathoms (45 meters), fine sand.

D.5146—Sulu Archipelago, vicinity of Siasi, Sulade Island (E.), N. 18° W., 3.40 miles (5° 46′ 40″ N., 120° 48′ 50″ E.). 24 fathoms (43 meters), coral sand, shells.

D.5161—Sulu Archipelago, Tawi Tawi Group, Tinakta Island (E.), N. 12° W., 1.80 miles (5° 10′ 15″ N., 119° 53′ E.). 16 fathoms (29 meters), fine sand with black specks.

D.5164—Sulu Archipelago, Tawi Tawi Group, Observation Island, S. 82° W., 8 miles (5° 01′ 40″ N., 119° 52′ 20″ E.). 18 fathoms (33 meters), green mud.

D.5181—Off eastern Panay, Antonia Island (S.), S. 63° W., 6.60 miles (11° 36′ 40″ N., 123° 26′ 35″ E.). 26 fathoms (47 meters), mud and fine sand.

D.5192—Off northern Cebu Island, Jilantaguan Island (E.), N. 13° W., 3 miles (11° 09′ 15″ N., 123° 50′ E.). 32 fathoms (58 meters), green sand.

D.5213—East of Masbate Island, Destacado Island (S.), N. 87° E., 8.50 miles (12° 15′ N., 123° 57′ 30″ E.). 80 fathoms (146 meters), sand, mud, shells.

D.5220—Between Marinduque and Luzon, San Andreas Island (W.), S. 57° W., 8.50 miles (13° 38′ N., 121° 58′ E.). 50 fathoms (91 meters), soft green mud.

D.5310—China Sea, vicinity of Hong Kong, off Pratas Island (21° 33′ N., 116° 13′ E.). 100 fathoms (183 meters), sand, shells, bottom temperature 65.5° F (18.6° C).

D.5311—China Sea, vicinity of Hong Kong, off Pratas Island (21° 33′ N., 116° 15′ E.). 88 fathoms (158 meters), coarse sand, shells.

D.5312—China Sea, vicinity of Hong Kong, off Pratas Island (21° 30′ N., 116° 32′ E.). 140 fathoms (252 meters), sand, small shells, bottom temperature 57.5° F (14.2° C).

D.5314—China Sea, vicinity of Hong Kong, off Pratas Island (21° 41′ N., 116° 46′ E.). 122 fathoms (220 meters), sand, broken shells, bottom temperature 59.5° F (15.3° C).

D.5336—Linapacan Strait off Observatory Island (N.), S. 42° W., 9 miles (11° 37′ 45″ N., 119° 46′ E.). 46 fathoms (83 meters), sand, mud.

D.5342—Malampaya Sound, Palawan Island, Endeavor Point (S.), S. 58° E., 0.5 miles (10° 56′ 55″ N., 119° 17′ 24″ E.). 14–25 fathoms (25–45 meters), gray mud.

D.5357—North Balabac Strait, Balabac Light, S. 65° W., 14.3 miles (8° 06′ N., 117′ 17′ 10″ E.). 68 fathoms (122 meters), coral, sand.

D.5358—Jolo Sea, Sandakan Light (Borneo), S. 34° W., 19.7 miles (6° 06′ 40″ N., 118° 18′ 15″ E.). 39 fathoms (70 meters), mud.

D.5360—Manila Bay, Corregidor Light, N. 74° W., 6.9 miles (14° 21′ N., 120° 41′ E.). 12 fathoms (22 meters), hard bottom.

D.5426—Eastern Palawan and vicinity, 30th of June Island, N. 29° E., 12.2 miles (9° 12′ N., 118° 28′ E.). 27 fathoms (49 meters), fine gray sand.

D.5593—Sibuko Bay, Borneo and vicinity, Mount Putri (sea tangent), N. 52° W., 17.2 miles (4° 02′ 40″ N., 118° 11′ 20″ E.). 38 fathoms (68 meters), fine sand.

Additional localities represented are: India, Japan (Awaji, Boshu? [Boshiu?, Boshin?],Kagoshima Strait, Kyushu), and Torres Straits. The map accompanying this paper (Fig. 9) will give more complete locality data on the living cucullaeids.

THE SPECIES PROBLEM IN LIVING CUCULLAEA

In the past, inadequate descriptions, figures, and locality data on living cucullaeids have caused much confusion concerning the number of species and their true identity. Most conchologists have believed that there were two living species, but a few have maintained that there were three, and still fewer have claimed that there was only one.

If specimens are examined from several localities, the bewildering array of variation becomes apparent at once. Specimens from southern Japan resemble those from New South Wales, but they are not identical with them. Cucullaeids collected in cooler waters seem to have flatter ribs, more periostracum, darker color, and a more subquadrate outline. Ornamentation varies on the two valves of the same shell, and this feature is more pronounced on some specimens than on others. Ribbing also varies with the amount of corrosion of the shell, the size of the shell, and the particular area on the shell where it is studied. Valve outline and hinge teeth vary from one locality to another. The specimens from southern Japan are subquadrate, and those from India are more subtrigonal in form. If conchologists insist on splitting the living cucullaeids into distinct species, then one species will have to be erected for the New South Wales specimens, another for the Queensland specimens, another for the southern Japanese and China Seas specimens, another for the specimens from India, and so on. I am prone to regard these variations, at most, as subspecies.

ECOLOGY AND DISTRIBUTION OF CUCULLAEA

Most of the ecologic data are taken from the records on the *Albatross* dredging sta-

tions. There are, however, a few additional observations scattered through the literature on Indo-Pacific mollusks. As far as I am aware, all data are based on dead specimens. Living cucullaeids prefer fine sand or mud bottoms, and they have not been reported at depths greater than 252 meters. They have been found most commonly at depths ranging from 15 to 150 meters but have been collected in as little as five meters of water. Bottom temperatures were recorded in only three Albatross stations where cucullaeids were found. These temperatures ranged from 14.2° C to 18.6° C; and probably the other stations would, for the most part, have a bottom temperature nearer the higher figure, for they were all at shallower depths than the one from which the lowest temperature was recorded. *Cucullaea* does not appear to be associated with coral reefs and seems to be able to withstand lower temperatures than reef corals. The fact that cucullaeids are not associated with reef corals may explain the gaps in their distribution.

Cucullaea labiata is a variable and wide-ranging species. It has been reported living as far west as the Gulf of Aden and near Djibouti on the African east coast, but it has not been reported further south along the African coast. In the Red Sea it has been reported only as "subfossil." *Cucullaea labiata* occurs in Mauritius but has not been reported from Madagascar, although the molluscan fauna of the latter island has been studied with some degree of completeness. The family ranges eastward and is found in the Persian Gulf, Gulf of Oman, India, Malaya, Siam, the Philippine Islands, and thence north and south to Japan and Australia, respectively. In Australia the known distribution of *Cucullaea* is from Melville Island in Northern Territory eastward and southward along the Queensland coast and into New South Wales as far south as Shoalhaven below Sydney. Chavan (1907, p. 307) reports *Cucullaea* from New Caledonia, but no one else has mentioned it from this region. Continued collecting may show that *Cucullaea* occurs farther west in Australia and also farther south along the east coast of Africa and perhaps in Madagascar.

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Dr. Joyce Allan, of the Australian Museum, gave me detailed descriptions and drawings of the Australian cucullaeids as well as data on their geographical distribution. Dr. L. R. Cox, of the British Museum (Natural History), looked for the type specimens of *Cucullaea granulosa* Jonas. The following persons gave geographical data from the specimens of cucullaeids in their collections: Wm. J. Clench, Museum of Comparative Zoology; Dr. Leo G. Hertlein, California Academy of Sciences; and Dr. A. Myra Keen, Stanford University. This study could not have been completed without the help of these persons.

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